PROBLEM OF THE VALUE OF THE LUNAR GRAVITATIONAL FIELD EXPANSION COEFFICIENTS  ${\rm C_{20}}$  AND  ${\rm C_{22}}$ 

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(NASA-TT-F-14605) PROBLEM OF THE VALUE OF N73-10858)
THE LUNAR GRAVITATIONAL FIELD EXPANSION
COEFFICIENTS C20 AND C22 S.T. Khabibullin,
et al (Scientific Translation Service) Unclas
Oct. 1972 5 p CSCL 03B G3/30 46067

Translation of "K voprosu o znacheniyakh koeffitsientov C<sub>20</sub>, C<sub>22</sub> razlozheniya gravitat-sionnogo poly luny". Astronomicheskiy Zhurnal, Vol. 49, No. 1, 1972, pp. 222-623



NATIONAL AERONAUTICS AND SPACE ADMINISTRATION WASHINGTON, D. C. 20546 OCTOBER 1972

## PROBLEM OF THE VALUE OF THE LUNAR GRAVITATIONAL FIELD EXPANSION COEFFICIENTS C20 AND C22

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ABSTRACT. The discrepancy between the values of the C20 and C22 coefficients (which define the polar and equatorial flattening of the dynamic configuration of the moon) obtained by Gapcynski, Blackshear, and Compton (1969) and previous values obtained by Lorell and Sjogren (1968) and by Michael et al. (1969) is analyzed. It is proposed to calculate these coefficients on the basis of the most probable values of the Cassini-equator inclination and of the g (prime) parameter defining the radial density distribution in the bulk of the moon.

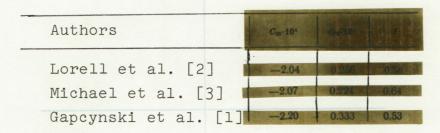
A new analysis of the Moon's gravitational field, based on track- /222\* ing data for Lunar Orbiters I to V, has been made by Gapcynski, Black-shear, and Compton [1]. In contrast with previous methods, the authors used observational intervals of from 1 to 5 days to compute the gravitational force potential parameters, thus affording improved definition of the higher coefficients.

We note that the values of the coefficients  $C_{20}$  and  $C_{22}$ , describing the polar and equatorial compression of the Moon's dynamic figure, and evaluated earlier by Lorell and Sjogren [2], and by Michael,

<sup>\*</sup>Numbers in the margin indicate pagination in the original foreign text.

Blackshear, and Gapcynski [3], differ noticeably from those presented in [1]. Table 1 below shows the values of these coefficients, referenced to the principal inertia axes [4].

TABLE 1



We recall that the ratio, f, of the differences in the Moon's moments of inertia is related to  $C_{2\,0}$  and  $C_{2\,2}$  by the formula:

$$I = \frac{C - B}{C - A} = \frac{C_{20} + 2C_{22}}{C_{20} - 2C_{22}}.$$
 (1)

Values of f are given in column 4 of Table 1.

The objective of the present paper is to direct attention to the fact that a comparison of results of Moon satellite trajectory measurements with data of astronomical observations of the Moon's rotation can contribute useful information to the problem of which values of  $C_{20}$  and  $C_{22}$  are correct.

It is well known that the Moon's dynamic compression depends mainly on the inclination I of the Cassini Equator to the Ecliptic. Again, the quantity  $\beta$  can be expressed in terms of the coefficients  $C_{20}$  and  $C_{22}$  and the parameter g' describing the radial mass distribution within the Moon, as follows:

$$\beta = -\frac{C_{20} - 2C_{22}}{C_{20} + 2C_{22} + \frac{2}{3}g'} \tag{2}$$

Since I has been reliably determined from observation (I =  $1^{\circ}33'$ ), it can serve as a criterion for choice of  $C_{20}$  and  $C_{22}$ , if g' is known.

At present, many data indicate that the mass distribution inside the Moon is close to uniform, which corresponds to g' = 0.60. We

adopt this value in estimating  $C_{20}$  and  $C_{22}$ .

TABLE 2

	Lorell [2	lichae:	1 [3]	Gapcynski [1]	
	B-10°	B-10°	1	p. 10	130 12
0.50 0.55	766 1°58′.2	756 687	1°56.′2 1 43.1	950 <sup>2</sup> 781	2715' 8 201.0
0.60 0.65 0.70	638 1 33, 8 589 1 24, 7 547 1 16, 7	630 581 540	1 32, 3 1 23, 2 1 15, 3	716 661 614	138.3 129.3

Table 2 shows values of the dynamic compression  $\beta$ , obtained for a number of values of g' and three values of  $C_{20}$  and  $C_{22}$ . Knowing  $\beta$  we can find the corresponding values of the inclination I. This was done using tables constructed by one of the authors of [5]. The values of I thus computed are shown in columns 3, 5, and 7 of Table 2.

It can be seen that for g' = 0.60 the value of I obtained for the data of Lorell and Sjogren "column 3) and of Michael et al. (column 5) is close to the observed value (1°33'), while for the data of Gapcynski et al. the value obtained is 1°49', which is very far from the observed value.

Hence we conclude that if the hypothesis as to the Moon's uniformity is near the truth, i.e., if  $g'\cong 0.60$ , there is a preference for the values of  $C_{20}$  and  $C_{22}$  obtained in [2] and [3]. The values of  $C_{20}$   $C_{22}$  obtained by Gapcynski et al. [1] require the assumption of g'=0.67, which corresponds to a noticeable increase in lunar density from the center to the surface, i.e., to a phenomenon which would be hard to explain.

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Translated for National Aeronautics and Space Administration under contract No. NASw 2035, by SCITRAN, P.O. Box 5456, Santa Barbara, California, 93108